This will create nearly 1,500 data bases, each with thousands of entries – clearly enough beyond easy human comprehension to require a new specialty of SysInformatics like that of BioInformatics to handle and apply the data efficiently. It is intended that these student workers will join with others doing their graduate M.S. or Ph.D. theses in Systems Engineering through the existing INCOSE SEANET program and other cooperating agreements between international SE educational programs. We are hoping the result will be a much wider knowledge base for new SEs of the future and the new SE discipline of the future as informed by systems science.

Proposed Protocol for Integrating the Systems Literatures

A Shared Method. At present the following dozen steps have been identified as the rubric or algorithm to get a unified systems science from the unconnected theories and wider range of sources just described. These headings are those intended for use in the online discussions and for the face-to-face Workshops sponsored by INCOSE, ISSS, or possibly IEEE-Systems. Some of the first steps here are the logical first steps but not the one's we jumped to do first. At the ISSS Workshop in San Jose we tried steps 6 and 7 to get a feel for how wide the experience base of participants was in that group. Steps 1 to 5 are logical precursors to the task, but they would likely generate so much preliminary and mainly philosophical debate that interest might wane before the meat of the matter was engaged.

At present, we anticipate that Steps #7 (what stuff shall we integrate), #8 (systems processes as the unifying framework), #9 (how those interact to make a system work), & #11 (how to identify when they don't work, why they don't work). Certainly each of these steps deserves full research paper coverage in the perspective of the overall task. The terms listed under each step are intended to help users imagine what might be addressed in that step. Compare #7 with the results of the lists obtained from participants in the ISSS'12 INCOSE Workshop (Table One).

(1) TYPES OF ARGUMENTS FOR/AGAINST UNIFYING SYSTEMS THEORIES (should we even attempt this task; advantages vs. disadvantages; strengths vs. weaknesses?)

• *Example Positions:* diversification is good; consensus is needed; utility for improved education; utility for improved communication/translation; advantages of discrimination, disambiguation; awareness of discinyms/nyms; excessive focus on personal synthesis; as a core knowledge base for SE, Sustainability, SS, SB, SN, ESS communities; cannot apply to all domains

(2) TYPES OF UNIFICATION or SYNTHESIS (make a general image of the product sought?)

• *Example Terms:* isomorphic; isomorphism; isomorph; homomorphism; discipline independent; domain independent; scale independent; tool independent;

(3) TYPES OF SIMILARITY (how get to the unification?)

• *Example Terms:* correlation, correspondence, metaphor, simile, allegory, analogy, homology, parable, story, symbol, we choose isomorphy;

(4) TYPES OF THEORY (what are we unifying?)

• *Example Terms:* evidence-based; experimental-based; mathematical-based; laws; abstraction levels; universal patterns; de-abstraction guidelines; solely logic-based;

(5) IDENTIFY ALL DOMAINS OF SYSTEMS WORK (across what categories are we unifying?)

• *Example Terms:* single isomorph; multiple isomorph; single domain/discipline; multiple domain/discipline; general; mathematical; method-based; tool-based; natural systems; science-based; social systems;

(6) TYPES OF SYSTEMS (across what taxonomy are we unifying? Are the taxonomies orthogonal?)

• *Example Terms:* open; closed; mature; immature; natural; social; human; physical; living; non-living; mechanical; biological; geological; astronomical; chemical; computer; symbolic; semantic;

manifest; cognitive; neural;

(7) IDENTIFY ALL CANDIDATE SYSTEMS THEORIES /or/ WORKS (what will be unified/synthesized?)

• *Example Terms:* Odum; Miller; Klir; Forrester; von Foerster; Auyang; Rosen-Kineman; Simon; Wakeland; Iberall; Warfield; Churchman; Beer; Boulding; Checkland; Weiner; Gel Mann; Troncale; etc. etc. the 75+ in Charts One to Three.

(8) TYPES OF SYSTEMS PROCESSES (or MECHANISMS) (evaluating this synthesis framework?)

• *Example Terms:* clusters of SoSPT 55 systems processes; or individual SPs in list; general systems lifecycle stage clusters; must be isomorphic

(9) TYPES OF META-RELATIONS (INFLUENCES BETWEEN SYSTEMS PROCESSES) (evaluating this synthesis framework?)

• *Example Terms:* linkage propositions; cross-level hypotheses; entailments;

(10) TYPES (or CHARACTERISTICS) OF HEALTHY SYSTEMS (crucial to defining dysfunction?)

• *Example Terms:* sustainability; dynamic equilibrium; adaptability; integrity; evolvability; emergent behaviors; dynamic behaviors; responsiveness; normal range of parameters; transtemporality-comparative temporality;

<u>(11) TYPES OF SYSTEMS DISEASES</u> (categories of dysfunction at systems level?)

• *Example Terms:* dysfunctions such as these cyberpathologies; rheopathologies; nexopathologies; heteropathologies; cyclopathologies; (see dedicated section below)

<u>(12) TYPES OF SYSTEMS TOOLS/METHODS vis a vis SYSTEMS PROCESSES</u> (how are tools or methods so important to SE & SS related to knowledge of systems processes?)

• *Example Terms:* include all in ISSS, IEEE, & SE listings; include all from I. Tibor’s list; etc. Relate each tool to the underlying systems processes it represents.

Call for Alternative Protocols & Tactics. At any moment in the procedure, this group could change its algorithm given good arguments for a better protocol. We are actively debating the procedure we are using and expect it to change even while we are implementing it. We hope this report will stimulate feedback and suggestions. A shortened version, for example, would be:

- ✓ Document Need for & Utility of (presumably for both SS and SE)
- ✓ Decide Strategy & Framework
- ✓ Decide Criteria for (Sources of; Science of; a general theory; a SE core curriculum)
- ✓ Identify Systems Domains and Relationship of Domains
- ✓ Identify Candidate Systems theories to be integrated
- ✓ Identify broadest Sources of knowledge to be integrated
- ✓ Describe images of products and delivery systems

There are also alternative tactics to consider and decide. For example, would it be better or more efficient to focus on <u>one Systems Process</u> and review all the many sources of Table One and Four for info on that process, /or/ would it be better to focus on <u>one Systems Source</u> in depth harvesting pertinent info for all the Systems Processes simultaneously. Or both may occur because different SSWG participants choose their preference. In any case, the availability of a standard, consensual framework will bring the work together in a unified whole.

Relationship with Other SSWG Projects. Jack Ring has a community of scholars engaged in discussions toward finding a fundamental “ontology” of systems for SE. Most of their debate also contributes to the task of unifying systems theories. If they can find an inherent, self-organizing ontology in the systems science database, it could be directly used in protocol steps 3 to 6 above. Some of the SEs and SSs involved in Ring's project are also contributing to this project. There is also a natural relation between the results of these two SSWG projects and its new efforts on Systems Education. A detailed consensus on a unified systems science would directly contribute to a curriculum for training systems engineers. Cross-fertilization between the projects gives rise to greater consistency in use of terminology which is a central goal of the Praxis Project of SSWG.

Guiding Tenets for the Project of Unifying Systems Sources

Principles or Working Assumptions? One of the needs identified by our workshops is putting the many results of various systems authors in some standardized, "atomic" form. By "atomic" we mean in the form of unit statements that can be learned, taught, tested, improved. Too much of systems authorship consists of very long descriptions and too little of nuggets for easy communication and application. We would strive to be more like the natural sciences. In the harder sciences, like physics and chemistry, there are formulae and laws that crystallize a large amount of supporting data on how things work. In still rather rigorous sciences like geology and biology, there are word statements that describe how phenomena work.

These word statements are concise, describe how their systems work, and are supported by a wide range of experiments. In fact, in cell and molecular biology entire recent texts of 1,000 pages are organized into numerous small sections titled by statements that capture the knowledge units about a phenomenon. They describe how it works. Thus some workers present Checkland or Warfields (2006) work in terms of "insights" or principles to apply to SE problems. In these projects we reject the temptation to call our "atoms" of knowledge, principles for the following reason.

Systems science has long had such terms as Deutsch's Law or Ashby's Law. But when one examines the origin of such laws, one does not find a large body of testing and support for the relation embodied in the law, but rather an intuitive appeal for the relation that gave it wide acceptance. They become almost urban legends. This is not science. In fact, these putative "laws" should not be called laws at all, but rather "conjectures" after the culture of mathematics.

So hereafter in this paper and our work, we will respect the need for "statements" of fact in the knowledge base, but will identify ours as "working assumptions" or perhaps "working hypotheses" to emphasize that while some support for these have been documented, we advise and allow only conditional acceptance until more testing is completed and a greater consensus has evolved. A list of these provides something of a list of "tenets" for the project of unifying systems sources. For example, we recognize…

Working Hypothesis 1: [UNITS] Both a "science" of systems and SE need a systems theory made up of a series of unit statements that are testable, teachable, correctable, improvable, and tightly coupled.

Working Hypothesis 2: [PROVEN] These unit statements can and must be documented or proven in the source literature. This project has the goal of providing a rigorously "evidence-based" systems thinking as a step toward a more usable "science" of systems (next section).

Working Hypothesis 3: [PROCESSES] General theories of systems should be based fundamentally on systems processes (SP) /or/ mechanisms as their fundamental constituent or basic units. It should be noted that is through the understanding of "transformations," "mechanisms" or "processes" that the natural sciences have succeeded so well and are so useful. Likewise, a systems theory based on processes may well be the most usable by systems engineers and other users of systems theory.

Working Hypothesis 4: [COMPLETE SET] A full set of systems processes are both necessary and sufficient. Using all of them, rather than just concentrating on one. Some people attempt to define all